reflected will again be reflected from the reflective electrode **12** until it does escape. Since light may pass repeatedly through the transparent electrode **16** and organic layers **14**, and be reflected from the reflective electrode **12**, it is helpful for the transparent electrode **16** and organic layers **14** to be as transparent as possible and the reflective electrode **12** to be as reflective as possible.

[**0033**] In any real OLED device, however, light will be lost to absorption and reflection. Therefore it is critical to both maximize the scattering of waveguided light and minimize the reflection from the scattering layer and absorption in the various layers. The scattering of waveguided light can be maximized by employing a light-scattering layer that has the maximum difference in refractive index between the light-scattering particles **70** and the surrounding environment. Hence, rather than employing light-scattering particles enclosed within a smooth layer of material, for example a polymeric matrix material having a refractive index of 1.5, the present invention employs light-scattering particles **70** that project into the gap **18**. Since the gap **18** is a vacuum or is gas-filled (where most gases will have a relatively low refractive index, e.g., typically approximate 1), light scattering is enhanced. In contrast, if a relatively higher-index solid material matrix is employed, a thicker scattering layer is necessary to achieve the same scattering effectiveness. Such a thicker layer will both absorb more light and reflect more light, causing the reflected light to pass through, and be reflected by, the various OLED layers more often, increasing the light absorption in the OLED layers.

[**0034**] Through experimentation, applicants have demonstrated that a maximum scattering effect with minimum light absorption and backwards scattering may be achieved through the use of scattering particles having an average maximum dimension size between 400 nm and 5 microns and, more preferably, having an average maximum dimension less than 2 microns and, even more preferably, having an average maximum dimension size between one micron and 2 microns and coated on an OLED with an average thickness of between about one and five microns, and, even more preferably in a coating with an average thickness of about one to two microns. Applicants have measured the overall light output of a variety of layers having different particle sizes, thicknesses, and adhesive binder. Referring to FIG. **3**, the light extraction efficiency of layers having different particle sizes for different colors of light is plotted. FIG. **3** illustrates the optimum case for the top-emitting OLED structure disclosed and claimed in the present invention. In this experiment, the light-scattering particles comprised commercially available titanium dioxide particles. The absolute improvement in extraction efficiency was actually greater than the Y axis of FIG. **3** indicates, because the use of an OLED device with a small active area (0.1 cm^2) in this study caused the devices with scattering layers to emit from a somewhat larger area than devices without a scattering layer, and the plotted values are radiance rather than total light output.

[**0035**] Applicants have also demonstrated that without some adhesive binder **74** to adhere the light-scattering particles **70** to the OLED, the layer of light-scattering particles **70** may not be mechanically robust. Hence, a small amount of adhesive binder **74** may be employed to adhere the light-scattering particles **70** to the OLED and promote optical coupling from the OLED to the light-scattering particles. The adhesive binder **74** may comprise a polymer, for example polythiophene, polycarbonate, PET, PEN, PEDOT, polyvinylcarbazole, or urethane. In a particular embodiment, Solsperse 24000™ polymer dispersant manufactured by Avecia Ltd may be employed. Since, according to the present invention, the light-scattering particles **70** project into the gap **18**, the adhesive binder **74** may not completely cover all the light-scattering particles to form a layer with a smooth surface. However, some portion of the adhesive binder **74** may be present on the light-scattering particles to cause them to adhere to the OLED and to each other to form a mechanically robust layer.

[**0036**] Referring to FIG. **4**, a top-emitting organic light-emitting diode (OLED) device of the present invention may be formed by a method comprising the steps of forming **100** an OLED over a substrate, the OLED comprising a reflective electrode formed on the substrate; one-or-more layers of organic light-emitting material formed over the reflective electrode; and a transparent electrode formed over the one-or-more layers of organic light-emitting material; coating **102** a dispersion comprising a solvent, relatively high-refractive index light-scattering transparent particles, and an adhesive binder over the OLED; drying **104** the coating to adhere the light-scattering particles to the OLED with the adhesive binder and form a light-scattering layer having a rough surface; and affixing **108** a cover to the substrate while forming a vacuum gap or a gap filled with a relatively low-refractive index gas between the cover and the light-scattering layer into which light-scattering particles project from the rough surface of the light-scattering layer without contacting the cover. If color filters are employed with the OLED device, the cover may be aligned **106** to the substrate before affixing **108** the cover to the substrate. Useful solvents may include toluene and xylene.

[**0037**] According to various embodiments of the present invention, the dispersion may be coated over the OLED by spin coating, ink jet coating, spray coating, or hopper coating. To aid in the formation of a thin layer that effectively scatters light with the minimum amount of light-scattering particles, a surfactant may be provided in the dispersion to discourage flocculation. In a preferred embodiment, the adhesive binder may itself also be a surfactant (e.g., Solsperse 24000™ polymer dispersant manufactured by Avecia Ltd). In other embodiments, the adhesive binder may be curable with heat or radiation. The present invention is preferred over some prior-art scattering layers in that expensive and potentially damaging processes such as photolithography or molding, or materials likely to introduce particulate contamination are not needed.

[**0038**] Applicants have demonstrated that a useful light-scattering particle layer with particles that project into an adjacent gap may be obtained by employing an adhesive binder that is less than 30% of the scattering layer by weight. Accordingly, when provided in a coating dispersion, the adhesive binder may comprise less than 30% by weight of the combined weight of the light-scattering particles and the adhesive binder. The concentration of solid materials (i.e., light-scattering particles and binder) combined preferably may be between 10% and 20% of the total coating dispersion by weight.

[**0039**] In preferred embodiments, the encapsulating cover **20** and substrate **10** may comprise glass or plastic with